International collaboration on local sand transport processes and morphological evolution

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LONG-TERM GOAL

To develop and enhance international collaboration in the area of coastal sediment transport processes.

SCIENTIFIC OBJECTIVES

The primary objectives of our collaboration are to further the theoretical and experimental investigations of the smaller-scale physical processes which must be encorporated in the development of a local model for sand transport and morphological evolution in coastal regions, including bedform prediction, local boundary layer hydrodynamics and a description of sediment dynamics covering the region from the immobile seabed to the overlying dilute suspension, encorporating both bedload and suspended load modes of sand transport.

APPROACH

We propose to integrate our various individual skills through a coordinated program of process evaluation, development, and validation. Process

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evaluation and development will be accomplished during this project by building upon existing theories and models and by utilizing the comprehensive data sets a) which have been obtained in large scale laboratories and field experiments, and b) which are currently being planned by us as part of various studies funded from other sources (e.g.SANDY DUCK, the EC MAST programme). Model validation will be accomplished in the latter part of the program through comparison with new data sets obtained during experiments which are already planned by the PIs and to which collaborating PIs will be encouraged to take part (e.g SANDY DUCK in 1997, the 1998 field program of the EC TRIDISMA project).

WORK IN PROGRESS

This contract began in May of FY97 and a kick-off discussion meeting was held during the Coastal Dynamics Conference at Plymouth in June 1997. Two collaborative ventures are now underway with exchanges both to and from the USA. The first is the Sandy Duck experiment (Sept-Nov 1997), at the US Army Corps of Engineers Field Research Facility, Duck, N. Carolina where Dr Dan Hanes has been joined by Dr Chris Vincent (UK) and a research student from Dr Khabidov's group in Russia. The small-scale bedform and suspended sand concentration measurements currently being undertaken at Duck are designed to investigate the role of ripple/mega-ripple dimensions in resuspension of sediments. A suite of instruments consisting of two Acoustic Doppler velocimeters, a pressure sensor, an OBS, a three-frequency profiling acoustic backscatter sensor and a novel Multi-Transducer Array (MTA), are now deployed at 4m water depth and intensive data collection is underway. The MTA will alow us to examine the response of the smaller bedforms (5cm - 2.5 m) to the action of individual waves or to a group of waves. Earlier measurements made by Dan Hanes and his students from the pier at Duck using the Sensor Insertion system suggest that the ripples can be almost wiped out by a single large wave but that they reform over the next few minutes. Such observations are unique and throw a completely new light on the complex feed-back processes which appear to control the resuspension of sand by waves and currents over a rippled bed.

The second Study is in Holland, at the University of Twente and the Delft Hydraulics wave-tunnel, where Dr Steve McLean is working with Dr Jan Ribberink and other scientists from the EC MAST project TRIDISMA (the 3-Dimensional measurement of Sand Transport by Acoustics) on problems relating to sheet-flow and suspension over flat beds. Their work focuses on the mechanics of sheet flow under waves and currents. This has included data anlysis and preliminary development of a process-based model of sheet flow. Also they are planning additional measurements in the large tunnel at Delft Hydraulics in November.

Preliminary measurements, to assess the possibility of measuring particle velocity within the sheet flow, have been analyzed and show great promise. The technique involves the deployment of two closely spaced (~20mm) concentration conductivity meters (CCMs). A correlation method is used to infer the particle velocity. For at least one of the wave-current condtions that were tried, the technique yields velocity records that clearly reveal both velocity and phase gradients within the sheet flow layer. The preliminry measurements only covered two wave-current conditions and only provided sparse vertical coverage of the layer, consequently, more detailed measurements are planned for November. These will provide a broader range of flow conditions and a denser vertical spacing of measurements within the sheet flow. In addition, turbulence measurements will be made at the same time, using the Delft Hydraulics laser-Doppler velocimeter. A relatively large sediment size (0.31mm) will be used to allow the LDV to approach the sheet flow layer as close as possible. Because of the large vertical extent of the large tunnel at Delft (0.8m) and the ability to produce oscillating flow speeds in excess of 1.5m/s, these turbulence measurements will be unique and extremely important for modeling efforts.

Most models of sheet flow, for the most part ignore the interstitial fluid except for the drag force that it provides. However, in dense sediment-fluid mixtures such as occur in sheet flow, the trapped interstitial fluid provides large resistance to relative motion between particles. With this in mind, McLean and Ribberink are collaborating on the development of a model that takes into account these particle-fluid interactions.

RESULTS

None.

IMPACT/APPLICATION

A successful process-based predictive model for bathymetric evolution (the morphodynamical model) can only be built upon an accurate model for local sediment transport (which is the integrated product of time-varying profiles of sediment-velocity and concentration). In addition to understanding the basic natural processes of coastal evolution, small scale sediment processes are also integral to understanding many engineering applications involving dynamics near the sea bed. For example, the transmission, scattering, and attenuation of light and sound near the seabed depend strongly upon the size and concentration of the suspended sediment.

TRANSITIONS

RELATED PROJECTS

Each of the co-Principal Investigators have ongoing related research projects.

REFERENCES

None.